3D Printing Magnetic Circuit Components for Hall Effect Thrusters, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The magnetic topography in Hall effect thrusters (HETs) plays an important role in focusing the electrons and controlling the plasma discharge which in turns governs the thruster performance. The magnetic circuit components constitute more than half of the thruster mass. To produce low-mass thrusters, the design of the magnetic circuit needs to be optimized. The advanced magnetic alloy (AMA) is the material of choice for the ferromagnetic parts of an HET's magnetic circuit. In addition to its superior magnetic properties, the AMA is also thought to be compatible with reactive propellants such as iodine. Currently, traditional machining is employed to fabricate these ferromagnetic parts. This results in removal of nearly 80% of the expensive bulk material which then goes unused. Additionally, traditional machining can cause unwanted deformation on thin parts, reducing the production yield. In Phase I, Busek and Oak Ridge National Laboratory (ORNL) propose to study the feasibility of 3D printing AMA magnetic circuit components. Our team will consider suitable additive manufacturing (AM) processes, including ebeam/laser AM processes, and a binderjet process with suitable binders. We will evaluate test coupons printed by ORNL by measuring their relevant magnetic properties and comparing them to those made using traditional machining methods. Additionally, we will apply relevant heat treatments to 3D printed test coupons and then re-measure their magnetic properties. The results will be compared to those made using traditional machining methods that were subjected to identical heat treatments. Based on the Phase I results, the best AM process will be down-selected to print a magnetic circuit component for the Busek 200W HET, with the goal of integrating it into the thruster in a potential Phase II program.

Anticipated Benefits

HETs enhance in-space maneuverability and payload capacity and are enabling for many NASA missions. The ability to quickly manufacture complex geometries will allow for more flexibility in the design of the HET magnets. AM will allow for more complex parts to be created and further optimization of the magnetic field which in turn will improve thruster performance.

Improving the technique in fabricating HET magnetic circuit components will make Busek's HET product more desirable to potential industry partners for flight missions. Busek's HETs span power levels from 100 W to 8 kW. The low power Busek Hall thrusters are attractive propulsion options for highly capable small satellites. Applications for high power Hall thrusters include orbit-raising and launch vehicle upper stages.

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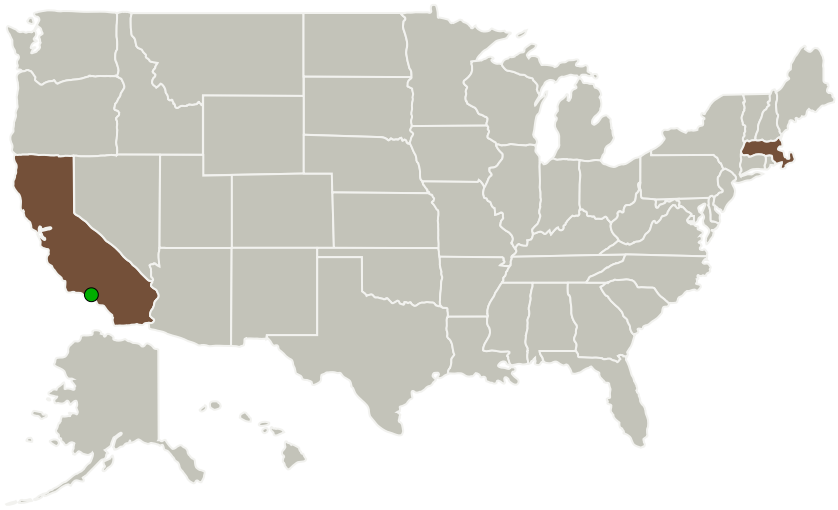
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Busek Company, Inc.	Lead Organization	Industry Women-Owned Small Business (WOSB)	Natick, Massachusetts
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Massachusetts

Project Transitions

August 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141187)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Busek Company, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

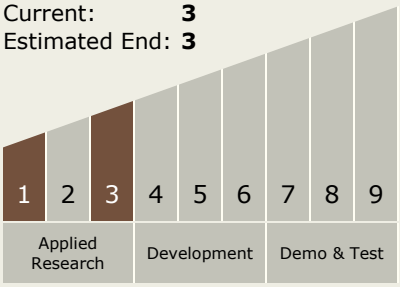
Carlos Torrez

Principal Investigator:

Yu-hui Chiu

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



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Images

Briefing Chart Image
3D Printing Magnetic Circuit Components for Hall Effect Thrusters, Phase I
(https://techport.nasa.gov/image/131011)

Final Summary Chart Image
3D Printing Magnetic Circuit Components for Hall Effect Thrusters, Phase I
(https://techport.nasa.gov/image/128535)

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.2 Electric Space Propulsion
    - TX01.2.2 Electrostatic

Target Destination

Earth